STUDIES ON THE PARASITIC WASP, HADROBRACON BREVICORNIS (WESMAEL).

II. A LETHAL FACTOR LINKED WITH ORANGE.

P. W. WHITING,

ST. STEPHEN'S COLLEGE, ANNANDALE-ON-HUDSON, N. Y.

Linkage of genetic factors has been demonstrated in many widely diverse species of plants and animals. In animals it may be complete in either sex, partial in the other; or it may be partial in both sexes. In plants it is apparently partial in both types of sporogenesis. Up to the present time linkage has not been demonstrated in Hymenoptera. In species which produce males by haploid parthenogenesis we might expect linkage in ovogenesis to be partial. In spermatogenesis linked factors would, of course, be completely linked as in the case of sex-linked factors in *Drosophila*. Unlike sex-linkage, however, there would be several independently segregating sex-linkoid groups, corresponding to the reduced number of chromosomes.

In the parasitic wasp, *Hadrobracon*, orange eye color is inherited as a sex-linkoid recessive to typical black. Heterozygous females produce black and orange males in equal numbers as previously shown.[1]

Three heterozygous sisters were isolated in July, 1920. One, a virgin, produced 38 black males and 44 orange males.

The second was bred as a virgin and later mated to one of her orange-eyed impaternate sons so that females were produced. Her progeny consisted of 57 black males, 44 orange males, 37 black females and 29 orange females. One of her black daughters isolated as a virgin produced 14 black males and 16 orange males.

Under normal conditions full-grown larvæ of the wasp spin cocoons before pupating which serve to attach them firmly in

[1] Whiting, P. W., "Studies on the parasitic wasp, *Hadrobracon brevicornis* (Wesmael)—I., Genetics of an Orange-eyed Mutation and the Production of Mosaic Males from Fertilized Eggs," BIOLOGICAL BULLETIN, Vol. XLI., No. 1.

the culture vial. If the supply of food is insufficient some of the larvæ pupate without spinning cocoons and are shaken into the ether bottle when the first count is made. If returned to the vial they will, in most cases, mature at the expected time.

The progenies of the heterozygous females above recorded consisted of black males, 104 adults, 5 pupæ; orange males, 101 adults, 3 pupæ; black females, 37 adults, no pupæ; orange females, 28 adults, 1 pupa. The ratio is quite in agreement with expectation and nothing unusual was noticed about the pupæ. Some of them would probably have metamorphosed to adults had they been replaced in the culture vial.

The third heterozygous black sister isolated as a virgin-produced offspring in an unexpected ratio. It was first noticed that the adult progeny were almost all orange and that there was an unusual number of small-sized pupæ without cocoons. Examination of the latter, moreover, showed that most of them had black eyes. It was immediately suspected that there was a lethal factor coupled with the normal allelomorph to orange. Consequently all pupæ were kept beyond the normal time of eclosion and those that failed to mature were counted as lethal. The black-eyed mother was mated to an orange son in an attempt to get black-eyed daughters carrying the lethal. The total progeny of this lethal-bearing female consisted of black males, 4 adults, 28 pupæ; orange males, 44 adults, 4 pupæ; black females, 2 adults, 3 pupæ; orange females, 18 adults, no pupæ. Among the females the excess of orange over black adults and the presence of black pupæ might seem to indicate partial dominance of the lethal factor. In any case the males show a striking departure from expectation. Black pupæ and orange adults would be *straights* and black adults and orange pupæ would be *crossovers*, except that a few of the pupæ might have failed to eclose on account of partial starvation. Among the males of this one fraternity there were 8 crossovers and 72 straights or 10 per cent. crossovers.

The two black-eyed daughters were isolated and later bred to orange sons. One produced black males, 5 adults, 17 pupæ; orange males, 23 adults, 6 pupæ; black females, 2 adults, 2 pupæ; orange females, 2 adults, no pupæ.

The other produced black males, 11 adults, 27 pupæ; orange males, 30 adults, 11 pupæ; black females, 3 adults, 1 pupa; orange females, 3 adults, 2 pupæ.

The lethal factor is therefore inherited, there being in this generation 33 crossovers and 97 straights or 25 + per cent. crossovers.

Although considerable care was taken to preserve the lethal stock it very rapidly died out due to difficulty in getting black-eyed lethal-bearing females, and moreover the total numbers in the fraternities became very small. Only three black-eyed females had offspring in the next generation and these were all males. One produced black, 5 adults, 27 pupæ; orange, 20 adults, 6 pupæ.

A second produced black, 3 adults, 12 pupae; orange, 15 adults, 4 pupæ.

The third produced all adults, 5 black and 9 orange. Although the numbers are very small in this last-mentioned fraternity the failure of any lethal pupæ to appear in spite of the presence of 5 adult black males is good evidence that the mother originated from a crossover or non-lethal black-bearing egg.

The total male progeny of all five lethal-bearing females is black, 28 adults, 111 pupæ; orange, 132 adults, 31 pupæ; 59 crossovers to 243 straights, or 19.5 per cent. crossovers.

Partial linkage is therefore demonstrated in Hymenoptera.

During the experiments above recorded a number of the lethal pupæ were fixed in Carnoy's fluid for histological examination. Sagittal sections, stained with iron hæmatoxylin, showed no abnormal growths or defects in any organs. The nature of the lethal effect is therefore unknown.